The Sidereal Messenger.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

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ON TELESCOPES OF SHORT FOCAL LENGTH.

BY H. L. SMITH.

In No. 28 *Science Observer*, I have given an account of the excellent performance of an achromatic telescope of short focal length made by Mr. R. B. Tolles, of Boston, Mass. I desire again to call attention to the advantages of such telescopes over those of the ordinary focal length to same aperture. Many years ago when the reflecting telescope, in the hands of Short, Watson and others was brought to a considerable degree of perfection, many excellent "Dumpys" as they were called were made, e. g. a Gregorian by Watson of 4-inch aperture was only eleven inches focus, and this short telescope showed ε Bootis neater than a 46-inch achromatic. The difficulty however in correcting short focal length telescopes, a difficulty much increased in the case of the achromatic, and the consequent extra cost of production, prevented their general adoption, and many of the earlier achromatics had focal lengths twenty or twenty-five times the aperture of the objective. The first, (then considered), large achromatic brought to this country—before we had a single artist competent to construct an achromatic telescope, was the

"Dollond" 5-inch at Yale college, and which had a focal length of ten feet. This telescope, had a triple object-glass full of bubbles and specks, but still sufficiently homogeneous to make a really capitally well corrected object-glass, and probably, for its day, unrivalled. In modern times the accepted ratio between aperture and focal length has been adopted as 1:15. Any increase of this ratio has been thought inadvisable as it necessitates not only thicker discs, but requires far more skill in the artist for proper correction of the spherical and chromatic aberrations. The first named objection, is of slight moment, the last is more serious, and necessitates a discrimination between a really good, and an indifferent artist. To-day we have constructors of achromatic telescopes, who are fully capable of dealing with the problem, and in the hands of these men, telescopes as perfectly corrected, of short focal lengths can be made as those of the old form—nay, in many respects, as I hope may appear, better. I am not aware that the Clarks, of world-wide reputation, (outside it may be of the construction of a comet searcher, which was not intended to do what is expected from the same aperture of the larger focal length upon close double-stars) have made what we may call a telescope, of unusually short focal length. Steinheil in Europe and Mr. Tolles in Boston have both devoted considerable time, and with no little success to the construction of such telescopes, and more recently Mr. John Byrne of New York has shown himself fully equal to the task of producing such instruments, of the very highest grade of excellence, and I am induced to give the following account of the performance of one lately received from him, not only for the sake of making better known the merits of Mr. Byrne as a telescope-maker, but also to show more clearly the advantages of the shorter focal length. In the division of close double-stars, highest excellence of figure, and consequent corrections, are not alone sufficient; the magnitude of the spurious images set a limit to the separating power. I have not Airy's treatise on the undulatory theory by me at present to refer to, but I am pretty certain that he gives the extreme diameter of a

star disc, in seconds of arc, to the first black ring, $\frac{5.52}{\text{aperture}}$ i. e. for 4-inch aperture 1.″38. We all know that the stellar discs are larger for brighter stars, and that the limit of resolving power to the aperture is much smaller than Airy's formula would give. Mr. Dawes, as the result of observation has given $\frac{4.6}{\text{aperture}}$, and Dallmeyer, $\frac{4.32}{\text{aperture}}$; now all of these, depend more or less upon relative focal length, for the longer the focus in proportion to the aperture, the smaller will be spurious images, and stars, which with a given aperture and focal length appear in contact, may show a distinct sky-line between, with same aperture and shorter focal length, and this even with less magnifying power, and less trouble therefore from tremor, and atmospheric disturbance. With a very high power, the star flits through the field with rapidity, and if one does not have the luxury of a pretty good driving-clock, and which could hardly be applied to a portable instrument, the constant necessity for movement by hand is detrimental to perfect vision. Some time ago I was looking at the minute double *s. f.* Procyon (31 Bode Cains Minoris), and with the power I was using, the two stars were in contact, at the time, the aperture of the object-glass was considerably contracted by a cap, on removing which, and using full aperture, the discs were so diminished in size that now a distinct sky-line was visible between them. In other words, I could, with same power, now separate a closer double than before. This fact however, is well enough known to observers, and I would only call attention to another, which appears pretty evident to me from actual experiment, viz: the stellar discs are not only more minute, but are apparent with far less magnifying power. I believe that, with the ordinary telescope, having ratio of aperture to focal length say 1:15, the discs are not well discerned with a less power than about 30 to the inch of aperture. Some have put it even 35 times the aperture. Now with the Byrne telescope of 4½-inch aperture and 38-inch focal length, I get very

beautiful stellar discs, without rings or rays on a fine night, with a power of 60, and even with a power of 40, which clearly separates the components of the quadruple star, ε Lyrae, of course to do this with so low power requires a good eye, but the power of 60 is quite sufficient, to show them far apart, and to indicate clearly the duplicity of π Aquilae, and with same power, I have seen repeatedly ε Cassiopea triple, of course, with all of these stars a power of 110 is better, and one scarcely ever needs, except for the very closest doubles, more than 150. With the latter power, produced by a very excellent one-fourth solid eye-piece by Tolles, there are no diffraction rings, or but a mere trace, and the clean shaven discs are really lovely. With 275 we get one or two diffraction rings, but even now faint, with this power ζ Herculis is shown, though at the present time, this rapid binary is almost too close for a telescope of this aperture, λ Ophinchi is readily seen with a power of 150. Of course the telescope is all one could ask upon planets. The solid eye-piece giving power 150, has shown to me Saturn with not a trace of the marginal blue light so often seen in the Munich telescopes, and most exquisitly defined, the shading of the outer ring, the crape ring, and the belts, in a manner that I have never seen surpassed, and rarely equalled in any telescope.

I do not unhesitatingly affirm, that I have (yet under the most favorable circumstances) seen closer doubles than same aperture of ordinary length would show, but I am certain I have seen them with *less magnifying power*, and that I can handle the whole instrument with far more ease, than if the tube had been the normal length; in fact, for the right ascension screw, no arm with universal joint is needed, the milled heads are within easy reach, and nothing can be more agreeable to use than this instrument with the star diagonal, and I have rarely used it without this. Neither can I say that more minute points of light are discernable with the "dumpy" for same aperture. The companion of α Lyrae, best seen with about 60 is steadily visible, when there was still enough daylight to see the second's hand of the watch, though after all, it was not much

more easily visible when the sky was darker owing to increased brilliancy of the larger star. The two faint stars (debilissima) between four and five ε Lyrae are of course, easy enough any clear night, and the companion of Polaris I have seen with a power of only 22. I dare say there are numerons telescopes of 4¼ aperture, and ordinary focal length which will show all I have named, but I have yet to see one that *with so low powers* will do this, and therefore am pretty certain, that if I had been able to use the instrument on a more firm foundation, and with still higher powers, I could have readily separated stars less than 1″ distance, and I am pretty certain that Mr. Byrne could make a telescope say of 9-inch aperture and seven feet focal length, that would separate any double-star now known, and prove a fair match for some of the gigantic, and necessarily more or less unwieldy instruments, bending under their own weight, if only some patron would give him the order.

In calling attention to the shorter telescopes and referring to Mr. Byrne's success, I only desire to state facts. I have already named Mr. Tolles' success with a telescope of same size, that telescope is now doing good service in China, where it was taken by one of my pupils, who, after long experience with the use of it, and abundant comparison with others of ordinary focal length, selected it as far preferable,—so far, that price was altogether a secondary consideration. Confident that Mr. Byrne could duplicate this telescope I parted with it, and have only been confirmed in my opinion of the superiority of the shorter focal length telescopes from my experience with the one he has sent me and to which I have alluded in this article.

The comet seems to be a fruitful subject of error—or, at least, of change of opinion. Prof. CHANDLER, who out-Heroded the sensation-mongers by saying the comet had actually gone through the sun, now sits in judgment on Prof. SMYTH, and the rest, with a new orbit showing no coincidence with the orbits of 1843 and 1880. He seems nearer the truth this time.—[*Knowledge.*]

RECENT EXPERIMENTS IN THE CONSTRUCTION OF TELESCOPE OBJECTIVES.

BY C. S. HASTINGS.

The writer has long been interested in the theory of the construction of achromatic objectives, not only on account of the extreme elegance of many of the problems involved, but also because, notwithstanding the vast amount of work which has been expended upon them for more than a century, complete solutions had not been reached; that is to say, no objective had ever been constructed under the guidance of theory alone. Indeed, it was the assertion made to the writer by the most eminent of living telescope-makers, that not only had no telescope ever been made according to theory, but that, in his opinion, none would ever be so made, which directed his attention to the subject.

From what goes before, it is evident that success was not to be hoped for by confining the effort to the mathematical aspect of the question, but, as the problem is distinctly a physical one, experiment alone could be expected to serve as an infallible guide. In short, abstract mathematical considerations could only lead to a certain conclusion, namely, that certain constants which enter the initial equations should have the same ratio as the dispersive ratio of the two varieties of glass concerned in the construction. Unfortunately, this dispersive ratio is absolutely indeterminate in all practicable cases, hence the necessity of experiment for testing the validity of any choice of a theoretical value for this ratio. The necessary preliminaries, however, were somewhat forbidding. In the first place, any theory would adapt itself to a sufficiently small objective, hence a rigid test could only be had by applying the theory to a large one; but not only would it greatly exceed the means at my disposal to have such a glass made, but, since all opticians are accustomed to work by tentative methods, it would only be possible to secure the requisite accuracy in shaping the curves by finding a skilled optician who would have faith enough in the theory to share something of its author's interest: of this, after several attempts, I

despaired. It only remained then, to educate myself to this most exquisitely accurate work as a preliminary step.

A certain amount of general knowledge of the methods pursued by lens-makers was acquired by visiting the various shops in this country, England, and Germany, which were readily accessible to me; to this was added the indispensable practical knowledge and dexterity for the purpose, by placing myself for a time under the instruction of a skilled optician in Paris. Then I purchased from Feil, the well known maker of optical glass a quantity of flint and crown as material upon which to experiment; deciding to make an objective of four inches aperture first. With the aims described in view, it was of the first importance to determine with all attainable accuracy the optical properties of these glasses. Prof. Becquerel kindly put at my disposal a Brunner spectrometer belonging to the *Conservatoire des Arts et Metiers*, with which a long series of measures was made upon prisms of the three varieties of glass to which the work was then restricted. The constants thus deduced were of great accuracy, but the final satisfactory values were only obtained sometime afterward with the admirable circle belonging to the physical laboratory of the Johns Hopkins University. In this investigation, the effects of variation of temperature were carefully determined and certain interesting and unexpected phenomena discovered, which formed the subject of a paper published in the *American Journal of Science*.

With the data thus acquired the curves for a four-inch objective from two of the glasses studied were calculated, such that the spherical aberration for rays of mean wave length should vanish, and under the hypothesis that the sum of the squares of the chromatic aberration for other wave lengths, weighted according to their respective luminous intensities, should be a minimum. This was the naturally suggested criterion for determining the most advantageous value for the dispersive ratio, and, although it did not differ very greatly from the method chosen by Fraunhofer without leading to a successful issue, it was hoped that the difference would be sufficient to correct his

error. The objective was carefully constructed according to these curves though it was first found necessary to improve the form of the spherometer so as to greatly increase its delicacy. The experiment proved a failure. Though the telescope was free from spherical aberration, thus proving the workmanship good; the color correction was decidedly too small. A careful remeasurment of the surfaces and a repetition of the computations demonstrated that the theory was certainly at fault.

A reconsideration of the whole subject gave rise to quite a different method of determining the most appropriate value for the dispersive ratio By it, the question of limiting extent of chromatic aberration was not considered at all, but only a condition as to the amount of light-energy sent very near the geometrical focal image of a distant point. This theory, (*American Journal of Science, Vol. XI, April, 1878*), after having been once formulated, was so satisfactory that there was no doubt as to its success even before testing it, but, as what follows will show, that did not lead to any neglect of rigorous tests.

In accordance with curves computed on this new basis the four-inch glass was again ground, polished and tested. In order to make the trial more severe the unusual ratio for focal length to aperture of 13 to 1 was chosen, as also a novel combination of surfaces by which the flint lens was brought in advance of the crown. The telescope proved an admirable one with corrections both for spherical aberration and color sensibly perfect. It has been used quite constantly since the early part of 1879 and tested by many observers; among others, by Prof. Holden, Director of the Washburn Observatory. Such objects as ξ Scorpii, ϵ Equilei, ζ Cancri (in 1882), η Orionis, ζ Herculis, δ Cygni, five of the satellites of Saturn even under ordinary conditions, the 5th and 6th stars of δ Orionis, and the companion to Sirius, all ofwhich had been repeatedly seen, serve as indications of its excellence. A few even more difficult objects, which either from exceptionally good visual powers or from not having been exhibited to others have been seen by me alone with this instrument, are not named; the list, however, contains one or two objects which have been seen, as far as I am aware, through no other telescope of the size.

(*To be Continued.*)

THE COMPUTATION OF A PARABOLIC ORBIT.

II

The formulas are:

$$\cot J = \frac{\sin(\lambda'' - L'')}{\tan \beta''}$$

$$M = \frac{T''' - T''' \sin\beta' \cot J - \sin(\lambda' - L') \cos \beta'}{T'' - T'} \quad \frac{T''' - T''}{T'' - T'} \cdot \frac{O}{P}$$

$$\sin(\lambda''' - L''') \cos\beta''' - \sin\beta''' \cot J$$

$$R''' \sin(L''' - L') = g \sin(G - L')$$
$$R''' \cos(L''' - L') - R' = g \cos(G - L')$$
$$\cos(\lambda' - L') \cos\beta' = \cos\phi'$$
$$\cos(\lambda''' - L''') \cos\beta''' = \cos\phi'''$$

(g is always positive, as are also $\sin\phi'$ and $\sin\phi'''$ which are to be found from $\cos\phi'$ and $\cos\phi'''$, or else from the formulas

$$\sin^2\phi' = \cos^2\beta' \sin^2(\lambda' - L') + \sin^2\beta'$$
$$\sin^2\phi''' = \cos^2\beta''' \sin^2(\lambda''' - L''') + \sin^2\beta'''$$

$$R' \sin\phi' = B' \qquad R' \cos\phi' = f'$$
$$\frac{R''' \sin\phi'''}{M} = B''' \qquad \frac{R''' \cos\phi'''}{M} = f'''$$

The computation follows in full:

$\lambda' - L''$	$-9°\ 0'\ 3''$
$\lambda'' - L''$	$-7°\ 24'\ 38''$
$\lambda''' - L''$	$-6°\ 25'\ 35''$
$T''' - T''$	1.0743
$T'' - T'$	1.7321
log sin $(\lambda'' - L'')$	$9.1105n$
log tan β''	9.7692
log cos J	$9.3413n$
log sin β'	9.5996
log sin β'''	9.7503
log sin $(\lambda' - L'')$	$9.1944n$
log cos β''	9.9626
log sin $(\lambda''' - L'')$	$9.0489n$
log cos β'''	9.9173

log $(T'''-T'')$	0.0311
log $(T''-T')$	0.2386
log sin β' cot J	8.9409n
Zech	0.4067
log sin $(\lambda'-L')$ cos β'	9.1570n
log O	8.7503
log sin $(\lambda''-L'')$ cos β''	8.9662n
Zech	0.6007
log sin β'' cot J	9.0916n
log P	8.4909
log $\frac{O}{P}$	0.2594
log $\frac{T'''-T''}{T''-T'}$	9.7925
log M	0.0519
$L''-L'$	2° 40′ 37″
log sin $(L''-L')$	8.6694
log R'''	0.00719
log cos $(L''-L')$	9.99952
log R''' cos $(L''-L')$	0.00671
Zech	2.995
log R′	0.00715
log g sin $(G-L')$	8.6766
log sin $(G-L')$	9.9999
log g cos $(G-L')$	7.012n
log tan $(G-L')$	1.665n
$G-L'$	91° 14′
G	184° 10′
log g	8.6767
$\lambda'-L'$	−7° 20′ 55″
$\lambda''-L''$	−7° 27′ 4″
log cos $(\lambda'-L')$	9.9964
log cos β'	9.9626
log cos ψ'	9.9590
log cos $(\lambda''-L'')$	9.9963
log cos β''	9.9173
log cos ψ''	9.9136

$\log \frac{R''}{M}$	9.9553
$\log \sin \psi''$	9.7582
$\log \sin \psi'$	9.6177
$\log f'$	9.9662
$\log B'$	9.6249
$\log f''$	9.8689
$\log B''$	9.7135

We have now the formulas:

$$\sin(\lambda''' - \lambda') \cos\beta' = h \cos\zeta \sin(H - \lambda''')$$
$$M \cos\beta''' - \cos(\lambda''' - \lambda') \cos\beta' = h \cos\zeta \cos(H - \lambda''')$$
$$M \sin\beta''' - \sin\beta' = h \sin\zeta$$
$$\cos\zeta \cos(G - H) = \cos\varphi$$
$$\frac{g}{h} \cos\varphi = \gamma \qquad \frac{g}{h} \sin\varphi = A$$

(h, $\cos\zeta$ and $\sin\varphi$ are always positive: $\sin\varphi$ may be found from $\cos\varphi$ or from

$$\sin^2\varphi = \cos^2\zeta \sin^2(G - H) + \sin^2\zeta)$$

The results from the formulas are

$H - \lambda'''$	70° 8′		
H	158 18	$\log\gamma$	8.5103
$\log h$	9·3810	$\log A$	9.2898

The next work is the computation of the distances of the comet from the earth (ρ) and from the sun (r), at the times of the first and third observations. The formulas are

$$2k(T''' - T') = \tau \text{ when } \log 2k = 8.536611$$
$$\frac{\rho' - f'}{B'} = \tan\theta' \qquad r' = R' \sin\psi' \sec\theta'$$
$$\frac{\rho' - f'''}{B'''} = \tan\theta''' \qquad r''' = R''' \sin\psi''' \sec\theta'''$$
$$\frac{\rho' - \gamma}{A} = \tan\theta \qquad s_1 = g \sin\varphi \sec\theta$$
$$\eta = \frac{\tau}{(r' + r'')^{\frac{3}{2}}} \qquad s_2 = \frac{\tau\mu}{(r' + r'')^{\frac{1}{2}}}$$
$$P'' = M\eta'$$

$\log\mu$ is given with the argument η in Table VIII of vol. 1

of Oppolzer. Below is a table large enough to serve in computing a preliminary orbit, when the comet does not approach very near the sun.

η	log μ	η	log μ	η	log μ
0.01	0 00000	0.16	0.00047	0.31	0.00179
0.02	0.00001	0 17	0.00053	0.32	0.00191
0.03	0.00002	0.18	0.00059	0.33	0.00204
0.04	0.00003	0.19	0.00066	0.34	0.00217
0.05	0.00005	0.20	0.00073	0.35	0.00230
0.06	0.00007	0.21	0.00081	0.36	0.00244
0 07	0.00009	0.22	0.00089	0.37	0.00258
0.08	0.00012	0.23	0.00097	0.38	0.00273
0.09	0.00015	0.24	0.00106	0.39	0.00288
0 10	0.00018	0.25	0.00115	0.40	0.00304
0.11	0.00022	0.26	0.00125	0.41	0.00320
0.12	0.00026	0.27	0 00135	0.42	0.00337
0.13	0.00031	0.28	0.00145	0.43	0.00354
0.14	0.00036	0.29	0.00156	0.44	0.00372
0.15	0.00041	0.30	0.00167	0.45	0.00390

A value is assumed for ρ', the distance of the comet from the earth at the time of the first observation. When the computation is executed, if s_2 be equal to s_1 ; the assumed value of ρ' is correct. But if the values of s_2 and s_1 differ, another value of ρ' is assumed, and the computation again made, and so on until a value of ρ' is found which makes $s_2 = s_1$. The correction ($d\rho'$) to be applied to each value of ρ' to get the next value is found by the formulas.

$$d\rho' = \frac{s_2 - s_1}{\frac{1}{2}\,\eta\,\mu\,(\sin\theta' + M\sin\theta'') + h\sin\theta}$$

When the true value of ρ' has been obtained, ρ''' is found by the formula $\rho''' = M\rho'$. For the first approximations, only 3-place logarithms are to be used. In the present case the writer happened to know that ρ' was about 0.31.

If nothing had been known of the value of ρ', the approximations with 3-place logarithms would have been made as follows. Two values of ρ', 0.1 and 0.5, or perhaps 0.5 and 1.0 would have been assumed, and for each of the values a computation made by the formula.

$$\frac{2\,k\,(T''' - T')}{\sqrt{2\,R\sin\psi'}} = m$$

$$\frac{\rho' - f'}{B} = \tan \theta' \qquad s_1 = g \sin \varphi \sec \theta$$

$$\frac{\rho' - \gamma}{A} = \tan \theta \qquad s_2 = m \sqrt{\cos \theta}$$

Inspection of $s_2 - s_1$ and the use of the rough formulas $d\rho' = \frac{s_2 - s_1}{h \sin \theta}$ would soon have led to the result $\rho' = 0.31$

Below are given two approxamations, except the determination of $d\rho'$ which was quickly made by a subsidiary calculation.

	ρ'	0.3100	0.2922
	f'	0.9252	
	f''	0.7395	
	γ	0.0324	
log	ε	8.9848	
	$\rho' - f'$	−0.6152	−0.6330
	$\rho' - f''$	−0.4295	−0.4473
	$\rho' - \gamma$	+0.2776	+0.2598
log	$(\rho' - f')$	9.7890n	9.8014n
log	B	9.6249	9.6249
log	$\tan \theta$	0.1641n	0.1765n
log	$(\rho' - f'')$	9.6330n	9.6506n
log	B''	9.7135	9.7135
log	$\tan \theta''$	9.9195n	9.9371n
log	$(\rho' - \gamma)$	9.4434	9.4147
log	A	9.2898	9.2898
log	$\tan \theta$	0.1536	0.1249
log	$g \sin \varphi$	8.6708	8.6708
log	$\cos \theta$	9.7594	9.7782
log	$R' \sin \psi'$	9.6249	9.6249
log	$\cos \theta'$	9.7523	9.7438
log	$R''' \sin \psi'''$	9.7654	9.7654
log	$\cos \theta''$	9 8861	9.8786
log	r''	9.8793	9.8868
	Zech	0.2977	0.2982
log	r'	9.8726	9.8811

log	$(r' + r'')$	0.1770	0.1850
log	$(r' + r'')^{\frac{3}{2}}$	0.2655	0.2775
log	η	8.7193	8.7073
log	μ	0.0000	0.0000
log	s_2	8.8963	8.8923
log	s_1	8 9114	8.8926
log	s_2	0.07876	0.07803
log	s_1	0.08154	0.07808
log	$s_2 - s_1$	—0.00278	—0.00005

Examining the differences $s_2 - s_1$, we see that the true value of ρ' is 0.2919. Hence we have

$$\log \rho' = 9.4652$$
$$\log \rho''' = 9.5171$$

The heliocentric longitudes (l), latitudes (b) and distances (r) come from the formulas below.

$$\rho' \sin(\lambda' - L') \cos \beta' = r' \cos b' \sin(l' - L')$$
$$\rho' \cos(\lambda' - L') \cos \beta' = r' \cos b' \cos(l' - L')$$
$$\rho' \sin \beta' = r' \sin b'$$
$$\rho'' \sin(\lambda'' - L'') \cos \beta'' = r'' \cos b'' \sin(l'' - L'')$$
$$\rho'' \cos(\lambda'' - L'') \cos \beta'' = r'' \cos b'' \cos(l'' - L'')$$
$$\rho'' \sin \beta'' = r'' \sin b''$$

r' and r'' must agree with the last values found in the approximations for ρ' and ρ''

In the present case we find

l' 275° 33′	b' 8° 47′
l'' 278 19	b'' 13 54
log r' 9.8813	log r'' 9.8868

If i denote the inclination of the comet's orbit to the ecliptic, and Ω the longitude of the ascending mode we have

$$\tan b' = \tan i \sin(l - \Omega)$$

$$\frac{\tan b'' - \tan b' \cos(l''' - l')}{\sin(l'' - l')} = \tan i \cos(l' - \Omega)$$

If $l'' - l'$ be positive, i is less than 90° ; otherwise i is between 90° and 180°.

We find

$$i \quad 62° \; 42' , \qquad \Omega \; 270° \; 59';$$

If tan i be numerically less than $\pm$ 1 we next use the

$$\tan u' = \frac{\tan (l' - \Omega)}{\cos i} \quad , \qquad \tan u'' = \frac{\tan (l'' - \Omega}{\cos i}.$$

If tan i be numerically greater than $\pm$ 1 we use the formulas

$$\tan u' = \frac{\tan b'}{\cos (l' - \Omega) \sin i} \quad , \quad \tan u'' = \frac{\tan b''}{\cos (l'' - \Omega \tan i} \quad .$$

The quadrant in which u lies is readily determined, since sin u and sin b have have the same sign; u denotes the angle between a radius-vector of the comet, and a line drawn from the sun to the comet's node; it is called the argument of latitude. To prove the accuracy of the work we have the formulas

$$S = \tfrac{1}{2} (r' + r'' + s)$$

$$\tan \tfrac{1}{2} (u'' - u') = \sqrt{\frac{(S - r') \ (S - r'')}{S \ (S - s)}}$$

We obtain

$u' = 9° \ 53'$ $\qquad\qquad$ $u'' = 15° \ 41'$

The perihilon distance is denoted by q: the true anomaly, or angle between a radius-vector, and the line from the sun to the perihelion point is v. The longitude of the perihelion point is π while ω is the difference between an argument of latitude and the corresponding true anomaly.

$$\frac{\cot \frac{1}{2} (u'' - u')}{\sqrt{r'}} - \frac{\operatorname{cosec} \frac{1}{2} (u'' - u')}{\sqrt{r''}} = \frac{1}{\sqrt{q}} \sin \tfrac{1}{2} v'$$

$$\frac{1}{\sqrt{r'}} = \frac{1}{\sqrt{q}} \cos \tfrac{1}{2} v'$$

$v'' = v' + (u'' - u')$ $\qquad\qquad$ $\omega = u'' - v''$

$\pi'' = \omega + \Omega$ $\qquad\qquad$ $\omega = u' - v'$

The values are

v'	12° 0′	ω	357° 53′
v''	17 48	π	268 52

log q 9.8764

The time of perihelion (T) is computed by the formulas

$$T = = T' - M' q^{\frac{2}{3}} \qquad T = T''' - M'' q^{\frac{2}{3}}$$

M' and M'' are taken from tabel V of vol. I of OPPOLZER, with the arguments r' and r''. If no such table is at hand we use the formula

$$M = \frac{\sqrt{2}}{k}(\tan\tfrac{1}{2} r + \tfrac{1}{3} \tan^3 \tfrac{1}{2} r$$

in which $\log \frac{\sqrt{2}}{k} = 1.914934$

The two values found for T are June 18.007 and 18.011. Gathering our results together, we tabulate them.

T	June 18.009 Washington M. T.
π	268° 52′
Ω	270 59
i	62 42
$\log q$	9.8764

COMET GOULD.

In speaking recently before a session of the Academy of Columbia college, N. Y., on the identity of GOULD'S comet with those of 1843 and 1880, Professor PETERS said substantially, that he could not agree with the claim made by some astronomers, that, because the comets of 1880 and of 1843, like this one, traveled very near the sun, moved in the same plane, had the same longitude of perihelion and of node, therefore the three comets are presumably one and the same, because this comet is so much brighter than the others were. Every comet is exhausting itself continually, and the substance which is thrown off in the tail does not form a plume, but is rather to be compared with the steam escaping from a steam-pipe. It is constantly renewed, until the substance of the nucleus is burned up. It is known now that the tail is a portion of the nucleus drawn out by electric force as the comet approaches nearer to the sun. The shape and curvature of the tail of any comet depend on its velocity. Three different types of tails exist, and under the spectroscope the composition of the three is

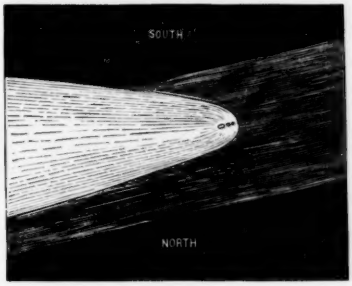
the same. The velocity depends somewhat on the nature of the tail. Three elements are known to exist. The lightest is hydrogen, which makes the longest tail. Next are the hydro-carbons, which form a medium-sized tail; and last is iron, which makes the shortest tail.

OBSERVATIONS OF THE GREAT COMET OF 1882.

BY E. E. BARNARD.

(*Concluded from page 223.*)

Oct. 15, a. m. The comet is of a pearly hue. In the telescope the head is composed of soft but dense light of this hue, through which the nucleus shines, appearing very long and large, with great quantity of coma. The streams of light running in front of the head have joined, and extend much further, and all in that direction, no separation into two tails, the light comes from away back along the middle of the tail, and is very abrupt at its outer edges.



Oct. 16, a. m. The tail toward the sun is faintly visible to the naked eye Some estimates of its position etc., show it to be 1° broad in a cross section through the head—fully four times as broad as the head—likely much more. The sides so far as I can make out are parallel to each other, the tail extending 4° or 5° in front of the comet's head. The southern side runs along the body (almost parallel with it) for 3° or 4° at least without joining, they at last seem to blend together at a great distance back of the head, no definite junction can be made out, it probably extends half the

length of the main tail, and possibly its full length.

This sunward stream of light is placed at a decided angle to the main tail, and, what is peculiar, lies in the axis of the nucleus—which has never, since it became elongated, been parallel with the main tail. The northern side of this stream of light is best defined—both sides clearly so. The appearance is as if the great comet had been laid down at a slight angle upon a broad flat stream of light. To the naked eye the end of the main train is still very plainly "swallow tailed," the southern part extending furtherest (south side of the tail has always been brightest and best defined) part of the time *slightly* convex toward the south.

Oct. 20, a. m. The sunward tial faintly visible to the naked eye. End of large tail abrupt and "swallow tailed." The sunward tail not quite so bright as formerly, but presented same appearance as regard junction with large tail etc. The nucleus longer than usual; its description is: (1)* not very well defined—long suspected a bright point at its *f* end; (2) bright stellar point with haze; (3) if there, very faint. The space betweet (1) and (2) plainly seen, clear and undoubtedly a separation.

Oct. 23, a. m. The comet is not so bright though still beautiful to the naked eye, with nucleus of at least 3rd magnitude. The end of tail as formerly. The sunward tail, with the telescope, is not so plain as before, but well seen, nucleus long and hazy, but separate into at least two parts; bright coma.

Oct. 24, a. m. Comet as yesterday—so end of tail. The sunward tail ruther dim in the telescope, seems to bend a little more toward the south. The space immediately in front of the head not so full of the hazy light as on former mornings, the densest parts seem to lie each side, as if separation into two tails again was emminent. The body of the comet now seems to blend more into this sunward tail.

Oct. 27, a. m. Bright moonlight, with high wind. The coma is very bright, nucleus bright but foggy and very long, seemingly only a very decided long brightening of the central part of the coma; it is inclined from the axis of the comet's head as heretofore; the principal division occasion-

*(1) Left hand, (2) middle, (3) right point of nucleus.

ally seen, but very indefinite. The sunward train and end of big tail not seen on account of moon-light.

These are observations of the comet up to the 27th of October, they will be continued as soon as the moon has withdrawn from the morning skies.

That the objects seen by me on the morning of Oct. 14, 6° south by west of the comet are in some manner connected with the presence of that comet seems highly probable, though in what way it seems impossible to tell. It will be remembered that Professor SCHMIDT at Athens, discovered a small comet 4° south-west of the great comet on the 8th of Oct. which, so far as I can learn has in some manner eluded the close search of observers generally; and later yet, Mr. BROOKS of Phelps, N. Y., reported a cometary mass 2° long 8° east of the large comet on the morning of Oct. 21st which he could not find on the 23d, and so far as I know has been seen by no other observer. These objects might be explained were it not for their visibility being so transient. One could easily believe in a number of companion comets traveling in the path of the great comet, but as for their only becoming visible for such a short time, that is something which will require explanation. I do not think that doubts of the observations should be entertained. I am positive of the realty of my objects. I might feel inclined to attribute them to the result of the explosion of a large meteor, being luminous masses left as the result of the explosion. But I am certain that no bright meteor had appeared in that neighborhood for at least an hour previous, and had they been such, from my experience in observing meteor smoke, they would have had quite a rapid motion, whereas their motion must have been very much slower than that of meteor smoke or it certainly would have been seen.

As to the separation of the nucleus of the comet, this has been corroborated by some observers and denied by others. Those who deny any separation admit that after the morning of Oct. 5th there were three or more bright condensations in the elongated nucleus. Whatever appearance the nucleus presented in a large instrument I most assured-

ly maintain that the appearance—whatever the realty—was that of decided separations with a great quantity of haziness present, which in large instruments might give the nucleus the appearance of continuity.

The observations were made with my five-inch Byrne refractor, a periscopic eye-piece of 78 being used unless otherwise stated.

NASHVILLE, Tenn., Nov. 1, 1882.

PROFESSOR HENRY DRAPER.

Like Agassiz and Professor Benjamin Peirce, Professor Draper was one of the few American scholars whose ardor for original investigation was never quenched with the routine work of the class-room. This is perhaps the sailent feature of the rich and fruitful life which has prematurely drawn to a close. Other men there are who, similarly endowed with the gifts of fortune, would have been content to follow the beaten path of instruction and to lead honored yet unproductive lives, shrinking from the pain and travail inevitable for the leader who wrests new truths from Nature's unwilling grasp. But Professor Draper proved himself the worthy son of an illustrious sire. Beginning physiological research when in his 'teens', his broad mind enabled him to pursue with equal zeal and with even greater results the subjects of chemistry, astronomy and especially celestial photography, in which his discoveries form the foundation upon which his fame as a scientist will most surely rest. As the first to obtain a photograph of the fixed lines in the spectra of stars, as the unequalled photographer of the diffraction spectrum, as the discoverer of oxygen in the sun and the bold exponent of a new theory of the solar spectrum, and as a successful photographer of the nebula in Orion, Professor Draper's memory will be held in honored remembrance among scientific men of all nations, while his work as Superintendent of the Photography Department at the transit of Venus in 1874 met with a degree of popular appreciation gratifying both to father and son.

One feature of Professor Draper's life adds a double distinction to the discoveries upon the character and composition of celestial bodies. His work was done alone from his private means, without aid from association or endowment funds, and his lavish expenditures upon his magnificent observatory and laboratory proved his inborn love for scientific research. Singularly happy in his power of imparting knowledge. his lucid interpretations of the principles of chemistry and physiology gave him a ready preeminence as an instructor. More than a scientist pure and simple, he was alive to the practical needs of the world around him, and the recent illustration of his signal success in regulating the motive power supplying electric lights showed services which will be of immediate and important practical use. And aside from the scientific research in which the keenly analytical qualities of his mind and his power of bold yet judicial deductions were seen to such marked advantage, Professor Draper's memory will be long cherished as an accomplished man of the world, gracious and genial in the drawing-room, holding his own in business circles, yet turning from every distraction with renewed ardor to the painful self absorption of his study and observatory. Wonderfully full and varied as his career has been, mingling so many diverse interests and pursuits, there is yet no one now, as at tne burial of William the Conqueror, to deny his right to a grave on account of unrighted wrong, for his life has been that of a modern Bayard, without fear and without reproach. *N. Y. Tribune.*

SCHMIDTS' COMET 1882.

Mr. HIND has completed the elements for the cometary companion to the great comet discovered by SCHMIDT.

T	Sept.	24.2773
π		334° 42′.6
ω		350° 2′.4
i		29° 11.5
log q		8.11394

Motion retrograde

EDITORIAL NOTES.

The great astronomical event of the month and year is the transit of *Venus*. A full report of the observations made in this country and abroad will be given in this and following numbers of the MESSENGER.

Professor D. GREENE, of Polytechnic Institute, Troy, N. Y., was only able, on account of cloudiness, to see *Venus* during the transit for a few minutes.

Professor MARIA MITCHELL at Vassar college observatory took observations of third and fourth contacts and photographs of the sun and planet. Miss WHITING of 1868 acted as assistant.

At the Naval observatory, Washington, D. C., Professor E. FRISBY used the twenty-six-inch equatorial and observed all four contacts.

The published times of the contacts are as follows:

1st	contact	8^h	56^m	45^s
2d	"	9	16	9
3d	"	2	38	57
4th	"	2	58	55

He saw no black drop, nor any irregularity whatever, only the true geometrical contact. JOSEPH A. ROGERS who has been acting as chief photographic adviser to the Commission also made observations for the contacts but the time was not reported.

Professor W. HARKNESS, observations as reported to us indirectly were:

2d	contact	9^h	16^m	23^s
3d	"	2	39	51

First and fourth contacts not given. During the afternoon when it was too cloudy to carry on the photographing, measures of the diameters of the bodies were taken with a double image micrometer. One hundred and fifty-three photographs were taken. The sensitive plates used were seven inches square, and the image of the sun was four and three-eighths, and that of the planet about one-eighth of an inch. Professor HARKNESS thinks that the photographs are much more valuable than contact observations can be.

Captain SAMPSON'S observations were made in the nine-inch equatorial and are as follows:

1st	contact	8^h	55^m	$9^s.96$
2d	"	9	16	18.96
3d	"	2	39	56.11
4th	"	uncertain.		

The black drop was seen at the end of the third contact.

Professor C. A. YOUNG reports that the observation of the transit at Princeton was very successful on the whole, though thin clouds interfered with the photographic operations.

All four contacts were observed; most of them by twelve different telescopes, ranging in size from three inches diameter up to twenty-three. Ten observers had each his own instrument. About a dozen others, members of the class in practical astronomy, observed the contacts on a screen.

The writer observed, with the twenty-three inch equatorial, the first and last contacts with the full aperture of the instrument, the second and third with the aperture capped down to six inches.

The first glimpse of the approaching planet was caught at $20^h\ 55^m\ 34^s$ (Washington mean time), but was probably due to the planet's obscretion of the chromosphere. The actual contact with the disc of the sun I put about six seconds later, at $20^h\ 55^m\ 40^s$. Others of our party caught it respectively at $55^m\ 58^s$, $55^m\ 50^s$ and 56^m. Those who did not catch it until later, recognized that the contact was already past when they first saw it. The second contact I observed at $21^h\ 16^m\ 19^s$. The observations of the others with one exception all lie between $16^m\ 07^s$ and $16^m\ 31^s$.

The third contact I wrote at $2^h\ 39^m\ 27^s$, the other observers ranging about 20^s ealier and later. The last contact occurred for me at $3^h\ 00^m\ 13^s$; the other observers lost the planet between 3^h and $3^h\ 20^s$, the accordance being better than at either one of the other three contacts.

One hundred and eighty-eight photographs were taken by Professor BRACKETT with an apparatus essentially the same as that used by the government parties. Notwithstanding the cloudiness the majority of the pictures were good.

The spetroscopic observations by Mr. McNeill and myself show unmistakably the presence of water vapor in the planet's atmosphere, and certain other lines of the picture not due to water, seemed also to be somewhat effected.

Between the first and second contacts the atmosphere of the planet was conspicuous as a delicate halo around its disc. Full sets of measures of the planet's diameter were made with double image and filar micrometers.

Professor E. C. PICKERING of Harvard Observatory. "During the recent transit of *Venus*, three observations of the first contact, four of the second and six each of the third and fourth, were made at the observatory. Photometric comparisons were made between the planet and the sky near the sun, showing the planet to be decidedly darker than the sky. Spectroscopic observation showed no peculiarity in the spectrum of *Venus*.

The mean results for the four contacts, in Greenwich mean time, are

$2^h\ 4^m\ 32^s$. $2^h\ 24^m\ 43^s$, $7^h\ 47^m\ 40^s$, $8^h\ 7^m\ 52^s$.

These results are derived from a preliminary reduction which may be liable to some slight correction."

At Dearborn Observatory Chicago, by Professors G. W. HOUGH and S. W. BURNHAM. "The observations for contact were made as follows:

Mr. S W. BURNHAM used the finder telescope; aperture 3¾ inches and power 60. Time r ecorded by stop watch. G. W. HOUGH, equatorial, aperture 12 inches, diagonal, power 190, time recorded on the chronograph.

Dr. H. D. GARRISON called time from a watch and recorded seconds.

At the time of first and second contacts it was perfectly clear and the seeing was good.

The first contact was observed as follows:

S. W. BURNHAM, $8^h\ 14^m\ 12.8^s$ a. m.
G. W. HOUGH, $8^h\ 14^m\ 06.7^s$ a. m.

Shortly after first contact a grayish light was noticed around that portion of the disc of *Venus* farthest from the sun, and at six minutes after the first contact, the whole disc of *Venus* was conspicuously visible both in the finder and the great equatorial.

At $8^h\ 32^m$, the outline of *Venus* was sharply defined, having the appearance of a solid black ball projected on the sun's disc.

As second contact approached no black drop or other phenomenon was seen, except that due to the atmosphere.

The following times were recorded in the chronograph:

(1) Suspected geometrical contact	$8^h\ 33^m\ 36.1^s$
(2) Certainly geometrical contact	8 33 54.2
(3) Clear sun-light around the planet	8 34 27.9

The atmosphere of *Venus* caused a haziness at the point of contact of the limbs of *Venus* and the sun, and a complete separation did not take place until the second of (3).

For some unexplained reason the chronograph reads one minute less than the recorded watch time for second contact

Mr. S. W. BURNHAM observed second contact at $8^h\ 34^m\ 45.7^s$

After the observations of contacts we arranged the telescopes to take a series of dry-plate photographs.

Between 9:30 and 11:15 Mr. BURNHAM and Dr. GARRISON exposed and developed ten plates, when further observations were stopped by clouds."

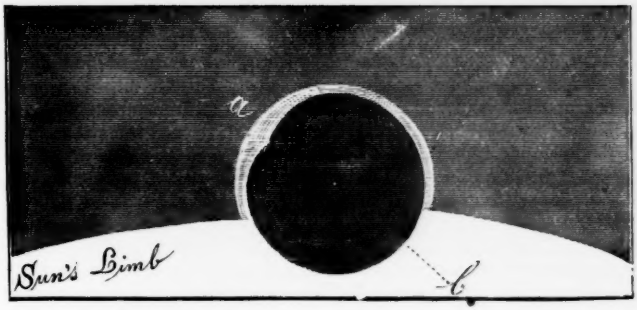
At Alleghany observatory Professor S. P. LANGLEY. "I prepared to observed the physical phenomena attending the entrance and transit of *Venus* rather than the times of contact, and directed my attention and that of my assistants beforehand specially to the study of the formation of the ring of light outside of the planet, between its external and first internal contact, (seen by other observers in 1874).

The seeing was through passing clouds and light haze

Shortly after first external contact a spot of light, looking at first like one of "Baily's Beads" in a total eclipse, was seen on the south-western limb of *Venus*, (*i. e.* on the part outside the sun). Its position-angle (estimated) was about 175° so that its position with regard to the chord joining the "horns" of the solar crescent was conspicuously unsymmetrical. It grew brighter, and extended for 30° along the planet's limb, tending a little toward the western "horn" as it increased. At this time the brightest part was so narrow that it was impossile to be certain whether it lay within or without the proper contour of the planet, but the impression was strong that the light was also carried inward toward the center of *Venus*. It seemed to be visible on the dark circle, for about ¼ of its radius from the circumference.

This was with the large equatorial and polarising eye-piece, but the phenomenon of a light-spot was also seen and described by Mr. KEELER, an assistant, who had received instructions beforehand to give his attention to the study of the formation of the light-ring and who gave the position angle of the spot as seen with a much smaller telescope, (before learning my results) within 10° of my own. This curious phenomenon was visible for at least eight minutes, undergoing modifications which I do not describe here in detail, finally uniting with, and presenting the aspect of a local enlargement of the left-ring. I have no hypothesis to offer as to its cause.

Pittsburgh, Pa., J. A. BRASHEAR observer; telescope, six and one-half inches silvered mirror with a bi-concave lens in front of the ocular, the side next to the diagonal being coated with a very thin film of silver; power 210. The following diagram shows the appearance of *Venus* at about 8½ minutes after first contact.



The ring of light entirely around the planet was first seen about three minutes previous, beginning at the limb of the sun it spread

around the disc of *Venus*, outside of the sun's image, which was itself pearly white. At the point marked *a* the illuminated arc was much broader than elsewhere, its deepest part extending in the direction of *b*, gradually diminishing for 15° each way.

Mr. Charles H. ROCKWELL, of Tarrytown, Westchester county, New York.

Lat. 41°	84′	23″.48 N.
Long. 73°	51′	33″.57 W.

Authority, United States coast survey; chronometer; Negus, number 1534. Correction, 43ˢ. Telescope 6¼ inch aperture, full solar prism, by Alvan Clark & Sons, power ninety. I took all four of the contacts quite satisfactorily, they were all slow of computed time as follows:

1st.	2nd.	3d.	4th.
.13ˢ.	.06.	05.6.	06.8.

At times a narrow rim or fringe was seen around the disc of the planet, showing the prismatic colors indicating an atmosphere. A group of small sun-spots was seen north of the planet between 12:30 and 1 p. m.

At Ann Arbor, Michigan, Professor M. W. HARRINGTON, director. "The weather here during the transit of *Venus* was very unfavorable. The first, second and third contacts were entirely hidden, and the fourth only unsatisfactorily seen through clouds.

From noon until shortly before the 3d contact the weather was nearly clear. Quite a number of measures of *Venus*' diameter were made. We thought we could make out several dark gray spots on the surface of the planet. Three of the observers agreed as to the location of one of these and two as to another, but they were too indefinite to be employed in testing the rotation of the planet. From the time *Venus* was half off the sun until about a minute before the last contact the defination was good. At that time I saw a broken ring of light about the part of the planet exterior to the sun. Above (in the telescope) it was about 1″ thick and fairly permanent for an arc of about 60° from the sun's edge. Below it was longer and thinner and somewhat fitful in apperance. On the part farthest from the sun for an arc of 20° or 30° I failed to see any light. About a minute before last contact the sun was again hidden by clouds which passed off just about the time of last contact but left the edge of the sun with so much boiling motion as to make the instant of contact uncertain."

Hobart College observatory, Geneva, N. Y., Professor H. L. SMITH observer. Contacts three and four of the transit of *Venus* were observed here through flying clouds. The sky was obscured entirely,

with the exception of two momentary glimpses, all the earlier part of the day. The 'black drop' or 'ligament' was seen distinctly at the third contact. The time given is when this first appeared.

Third contact $2^h\ 38^m\ 59.2^s$
Fourth contact $2^h\ 59^m\ 12.^s$
Latitude $42°\ 51'\ 37''\ \pm$ N.
Longitude 17^s east of Washington.

Ohio State University, Columbus, Professor R. W. McFARLAND, observer, and FRANK H. ELDREDGE, assistant.

Latitude 40° 0′ 35″; longitude from Washington, D. C., $33^m\ 49.9^s$ W. The first and second contacts were obscured by clouds.

Third contact $2^h\ 16^m\ 13^s$
Fourth contact $2^h\ 32^m\ 53^s$

with a possible error of a few seconds in the laat observation, as clouds again interfered so that the contact is a little in doubt.

Telescope four inches clear aperture, power, 170, makers ALVAN CLARK & SONS, 1881. Break circuit clock was made by NEGUS, N. Y. Time by chronograph.

At Dartmouth College, Hanover, N. H., the sky was overcast with clouds, so that Prosessor C. F. EMERSON could not get any contact observations of the transit. The clouds broke away soon after 10 o'clock and it was very clear from half past eleven to one o'clock, which time was spent in showing the transit to visitors.

Red House observatory, Phelps, N. Y. Professor WILLIAN R. BROOKS observer.—"I obtained a good observation of the transit of Venus at ingress securing the internal contact which I make $9^h\ 16^m\ 23^s.53$ Washington M. T. Time was recorded by Mrs. Brooks from a chronometer compared with Washington noon signals. The external contact was lost by clouds, also the last contacts. First view was had at about three minutes before the internal contact, when a luminous ring was seen to encircle the dark segment of Venus that was outside the sun. But of much greater importance was the discovery of several very faint patches of light on the dark disc of Venus. These were I think portions of the planet of a lighter color and higher reflective power than the rest, and were illuminated by the refraction of the planet's atmosphere. The definition was very good, the cusps well marked and no "black drop" was seen. Clouds prevented the photographing of the transit for which careful preparations had been made, but I am happy to have seen all I did of the great event.',

THE COLLIMATING EYE-PIECE.

The following list of dates may have some interest. The collimating eye-piece was first proposed (by BOHNENBERGER) in the *Astronomische Nachrichten* Vol. IV. p. 330 in..... 1825.
Used at Madras Observatory..... 1834–8.
Tried at Koenigsberg .. .. 1837.
Used at Edinburg for nadir..... 1840.
Used at Oxford for nadir..... 1843.
Used at Cambridge..... 1845.
Used at Washington ..... 1845.
Used at Greenwich..... 1847.

E. S. H.

ELEMENTS OF THE GREAT COMET OF 1882.

(Communicated by Vice-Admiral Rowan, Supt. U. S. Naval Obs'y.)

The following elements were computed from three observations at the U. S. Naval Observatory; the first and last being made with the transit circle, and the middle one compared with a known star which was afterwards observed on the transit circle:

Wash. M. T	App. α	App. δ
	h m s	° ′ ″
Sept. 19.9697877	11 14 18 94	− 0 34 29.7
Oct. 8.7204363	10 28 6.63	−10 40 22.6
Nov. 24.7009228	9 6 16.22	−27 21 26.7

From these observations we deduce

Perihelion Time = Sept. 17.2228200 Greenwich M. T.

Ω	= 346 1 7 91	
$\pi-\Omega$	= 69 36 12.79	
i	= 141 59 52.16	
φ	= 89 7 42.70	1882 0
$\log a$	= 1.9331366	
$\log q$	= 7.8904739	
Period	=793.689 years	

$$\delta\lambda \cos\beta = -0^{\circ}\ 0'\ .06''\qquad \delta\beta = +0'\ .01''$$

$x = r\,[9.9951411] \sin (170\ 42\ 12.72 + v)$
$y = r\,[9.9877234] \sin (262\ 46\ 57.39 + v)$
$z = r\,[9.4435130] \sin (49\ 20\ 25.11 + v)$

The observations as given were afterwards corrected for parallax by means of elements previously computed. These elements bear a considerable resemblance to Comet I. B. C. 371; and it may possibly be its third return, a very brilliant comet having been seen in full daylight A. D. 363.

E. FRISBY,
Prof. Math., U. S. N.

WASHINGTON, Dec. 19, 1882.

CONSTANT OF PRECESSION.

Dr. G. L. E. DREYER, (now director of the Armagh Observatory), has published "A new determination of the Constant of Precession" which is founded on a comparison of the stars common to the *Histoire Celeste* of LALANDE and to the 10,000 stars of SCHJELLERUP.

An analysis of the contents of the paper itself is not possible here, and it is moreover unnecessary since Dr. SCHOENFELD (V. T. S. *der Ast. Gesell.* 1882 p. 249), has published a thorough review of this important paper. Dr. SCHOENFELD has also added some theoretical considerations in regard to the general question of the determination of this constant which make his review more than a mere review; an important original contribution, rather. It may be said that Dr. DREYER'S result does not differ widely from the received constant.

Mr. JOHN R. HOOPER, of Baltimore, Md., recently sent us valuable notes and a number of excellent drawings of GOULD'S comet.

We take great pleasure in acknowledging the receipt of a series of celestial charts from Dr. C. H. F. PETERS, Litchfield observatory of Hamilton college, Clinton, N. Y. A full notice of this important work will appear later.

Professor E. C. PICKERING will soon find time to arrange further the details of his new plan for the study of the variable stars; we shall then seek early opportunity to place this interesting branch before our readers.

Much general matter has given place, this time, to the transit news and the orbit computations, and we have added two pages to the usual size of the MESSENGER in order to secure needed variety.

Professor SWIFT has prepared a drawing of the comet showing its sunward train somewhat like that given by Mr. BARNARD in this issue.

Mr. BARNARD has also prepared a very neat drawing of VENUS as it appeared between first and second contacts in two different positions, with the fine arc of light partly surrounding the planet's disc.

MARTIN WINGER, observer, at Cleveland, O., telescope with aperture $4\frac{1}{5}$ inches. The objects aimed at mainly in observation were the atmosphere and satellite of *Venus*, the 'black drop' and the contacts. During the transit, no traces of an atmosphere were seen, but as the planet approached the second internal contact the 'black drop' was seen, and on account of it the time of that contact was uncertain. The last contact was at

$2^h\ 41^m\ 35^s$ Cleveland local time.

P. F. HARRINGTON, Commander, U. S. N., Head of the Department of Astronomy, Navigation &c. U. S. Naval Academy, kindly furnishes the following data respecting the transit of *Venus*:

First contact uncertain				
Second contact	9h	16m	12.s6	Commander HARRINGTON, observer.
Third contact	2	39	34.3	Commander HARRINGTON, observer.
" "	2	39	32.8	Lieut. EATON, observer.
" "	2	39	27.3	Lieut. SEBREE, observer.
Fourth contact	3	00	04.4	Commander HARRINGTON.
" "	3	00	04.4	Lieut. EATON.
" "	3	00	09.4	Lieut. SEBREE.

A full account of the observation of the transit is received from Observer E. L. LARKIN of New Windsor, Ill. It will be used later to illustrate the details of this class of observations. The times of contact at New Windsor observatory, in mean local time, were

1. 8h 1m 51s
2. 8 22 20

Latitude + 41° 13′
Longitude 53m 53s west of Washington.
The 'black drop' was not seen.

From Fort Dodge, Iowa, Observer HESS reports that the weather was bad, Dec. 6, during the transit hours. The fourth contact only was observed by me at

3h 00m 22.5s Washington mean time.

I have heard from two sections on the A. T. & Santa Fe R. R. From Trinidad, New Mexico, Mr. E. TREADWELL reports bad weather.

From La Junta, Colorado.

Latitude 37° 58′ 54″, longitude 1h 45m 58s west of Washington, Mr. W. H. EARLE observed

Second contact at 9h 17m 0s
Third contact at 2h 41m 52s

Washington mean time.

At Warner observatory, Rochester, N. Y., Professor L. SWIFT intended to use the new Clark refractor in observing the transit of *Venus*. This noble instrument of sixteen inches clear aperture had been mounted only one week, yet it was ready for excellent service, doubtless, at the Professor's bidding but for those tantalizing clouds. He says: "My first view of the sun, for an instant only, was at 8h 57m 7s, when it was fairly notched, and the planet one-third of her diameter (estimated) on the solar disc." Two other glimpses only were had during the transit time.

At Cambridgeport, Mass., E. F. SAWYER and J. R. JEWETT, observers; a refracting equatorial telescope of four inches aperture, made by Mr. CLACY, of Boston; focal length only 44 inches; power used 150. The object-glass was smoked for direct vision by Mr. CLACEY, and it is said to have worked well. The first contact of the transit was lost. The second, a perfect geometrical contact, was observed at $9^h\ 39^m\ 45^s$ Cambridge mean time. No 'black-drop' was noticed. The interval between contacts following, was used in looking for satellites, bright spots, and a bright halo around the planet, but nothing of this kind was seen.

The third contact was at $3^h\ 2^m\ 56^s$. C. M. T.

At $3^h\ 13^m\ 53^s$ *Venus* appeared to be about one-half off the disc of the sun. Last contact was recorded at $3^h\ 23^m\ 37^s$. C. M. T. No 'black drop' was seen. *Venus* was not seen after leaving the sun's disc.

At Brooklyn, N. Y., G. P. SERVISS, observer; used a BYRNE equatorial, aperture, $3\frac{3}{8}$ inches, a solar prism, and powers 65, 110 and 215, alternately. "With the lowest power I saw the on-coming planet looking like a black speck, which instantly lengthened into a line, and then deepened into a notch. At the second contact there was no 'black drop', only a little indefinite shade which did not prevent my seeing the geometrical contact of the circular edges of the planet and the sun. When the planet was a little more than half on, its atmosphere outside the sun's disc showed beautifully, as a delicate arc of light spanning the gap in the sun's edge like a silver-lined rainbow. After the planet was fully on the disc, its black surface plainly appeared to be mottled with lighter and darker regions. This appearance was clearly seen with different magnifying powers. I kept no record of the times of contact but confined my attention to watching for peculiarities, in the appearance of the planet."

At Providence, R. I., F. E. SEAGRAVE, observer assisted by Professors JOHNSON and ALLEN. The first contact was lost in consequence of clouds. The second was noted at

$21^h\ 38^m\ 22.5^s$ Providence mean time.

Mr. SEAGRAVE'S Clark equatorial of $8\frac{1}{4}$ inches was capped down to four inches for the observation. Professor JOHNSON'S telescope was placed in the open air, and he observed the internal contacts, and took several sets of diameters of the planet with a double image micrometer. Professor ALLEN succeeded in getting thirty good negatives which have since been developed, and they are thought to turn out well. At the internal contact, the 'black drop' was very carefully looked for, but was not seen by any. Third and fourth contacts were lost by clouds and haze.

Iowa City, Ia., C. W. IRISH observer. "On the morning of the 6th I began to examine the sun at $7^h\ 58^m$, it was much serrated and very

unsteady owing to the agitated air of that low altitude; at that time I saw no sign of the planet.

At $7^h\ 58^m\ 30^s$ a thin cloud covered the sun and at $7^h\ 58^m\ 45^s$ I saw, as I thought, a notch where the planet should appear, the cloud passed off at $7^h\ 59^m\ 43^s$, I was sure that I saw the advancing planet. The times above are local mean time. The times of first sight and other phases are as below in Washington true mean time.

(1) $8^h\ 57^m\ 08^s$; Notch first seen through clouds.

(2) $9^h\ 07^m\ 42^s$; Planet's atmosphere seen on the following limb as a beautiful and very thin crescent, with an enlargement near the middle of it.

(3) $9^h\ 16^m\ 42.9^s$; Horns sharply defined and approaching.

(4) $9^h\ 16^m\ 50.4^s$; Horns rapidly approaching.

(5) $9^h\ 16^m\ 54.9^s$; Horns meet, limbs appear to be tangent to each other.

(6) 9 16 57.9; First flash of sunlight behind the advancing planet.

(7) 9 17 28.4; Second contact surely past.

Clouds the balance of the day.

In my opinion the moment of second contact was at the time of No. 5 or not later than one second after that, or at $9^h\ 16^m\ 55.9^s$, and it surely lies between the (5) and (6) observations.

The position of my station is in north latitude $41°\ 39'\ 45''$, and longitude in time west from Washington, $57^m\ 51.78^s$.

At Cincinnati, Professor H. C. WILSON, acting director. "The observations of the transit of *Venus* here were a failure. Clouds totally obscured all four contacts. Between first and second contacts *Venus* was visible for four or five minutes through thin clouds. Between second and third contacts several good views were obtained, but there were but a few minutes when I could not use the full aperture of the eleven inch equatoral without sun-shades. Between third and fourth contacts *Venus* was again visible for about a minute at $2^h\ 21^m$ local mean time. As nearly as I could estimate, *Venus* was then just half off the disc of the sun."

Haverford College observatory, Professor I. SHARPLESS Director.—"The contacts of *Venus* with the sun were satisfactorily observed here, the Wasington mean times of which were as follows:

8	56^m	15^s
9	15	49
2	39	33
2	59	51

At the times of first and second contacts, a light haze overspread the sky which did not prevent *Venus* from being distinctly seen. The temperature was moderate so that no inconvenience was experienecd from this source.

The limb of the sun was moderately steady at the time of the first contact, quite unsteady at the second, very distinct at the third, and unsteady again at the fourth.

Venus came on just where it was expected, and the first indication of a notch was recorded. At first internal contact there was no distinct 'black-drop' but every thing was quivering so that the time can not be considered accurate within three or four seconds. At second internal contact all conditions were favorable and *Venus* touched the disc of the sun as definitely as an artificial transit apparatus. By last contact considerable change in the state of the atmosphere had taken place and the exact time of the disappearance of the notch could not be determined within two seconds.

There was an appearance of an atmosphere to *Venus* in our telescope. This was looked for by several good observers.

Several measurers of the diameter of *Venus* while on the sun were made with a filar micrometer.

The observations were made with an $8\frac{1}{4}$ inch equatorial cut down to 6 inches, with a reflecting prism, a piece of light colored glass, and an eye-piece magnifying 200 diameters.

Professor S. P. LANGLEY has submitted to the Chief Signal Office an abstract of the results of the Mount Whitney Expedition to determine the amount of heat the sun sends to the earth; in technical terms, the solar constant. Mount Whitney, in Southern California, was selected for the observation because it combined the advantages of great elevation, extreme dryness of atmosphere, and abrupt rise from the plain. The party of observation consisted of Captain O. E. MICHAELIS, United States Army; two non-commissioned officers of the Signal Service, six soldiers acting as an escort, four civilian assistants, and Professor LANGLEY. Systematic work did not commence until the last days of August, 1881. Professor LANGLEY summarizes the results ascertained as follows:

"The approximate estimate of the solar constant is from 2·6 to 3·0 calories, by which is meant that the direct solar radiation before absorption by the earth's atmosphere would in falling for one minute, normally, upon an area of a square centimeter, raise the temperature of one gramme of waler 2·6 or 3·0 centergade. This implies its abil- to melt annually a crust of ice covering the whole earth over 150 feet thick. This amount is one half greater than the received value of POUILLET, and greater than the latest determinations of Messrs. CROVA and VIOLLE."

On the summit of Mount Whitney an ordinary black bulb thermometer *in vacuo* rose 130 degrees Fahrenheit, while the temperature in a blackened copper vessel, covered by two sheets of common window glass, rose above the boiling point. With such a vessel water could be boiled among the snow-fields of Mount Whitney by the direct solar rays.

While the influence of the atmosphere is to shut off from the earth's surface a considerable portion of the sun's heat by absorbing it, the capacity of the air to store heat and prevent its radiation into space serves to make the earth habitable. Otherwise, in Professor LANGLEY's opinion, the surface temperature, even under the tropics, would be lower than the lowest recorded degrees of Arctic cold. Another effect of the selective absorption of the atmosphere is to change the apparent color of the sun In a transparent atmosphere the now "golden sun" would appear blue.

SAWYER'S VARIABLE

Mr. S. C. CHANDLER has made the very interesting discovery that the period of the star, D. M. + 1°, No. 3408, is not $5\frac{1}{4}$ days as was at first supposed, but considerably less than one day, viz. $20^h\ 7^m\ 41^s.6$. The error arose from the star having been visible for some time only in the early evening. The minimum could therefore only be observed at intervals of 5.03 days, *i. e.* 6 periods, or sometimes 5.87 days, *i. e.* 7 periods. A combination of these resulted in the period assigned. All the variations from maximum to minimum, and back to maximum are accomplished in about four hours, the maximum brightness being maintained for sixteen hours. This star therefore has the shortest period known, and is the most remarkable for the rapidity of its changes. The duration of increase and of decrease apppears to be exactly equal; and the range is about seven tenths of a magnitude, from 6.0 or 6.1 to 6.7 or 6.8.—*Observatory.*

Photometric Observations of Comet Wells.—Exact photometric observations of comets have been somewhat rare; but DR. MULLER, of Potsdam, has succeeded in obtaining a good series of observations of Comet Wells with a Zollner's photometer attached to one of STEINHEIL's refractors. Having found considerable difficulty in measuring the brightness of a comet with this photometer, owing to the great difference in appearance between the comet and the artificial stars, he removed the disk that bore them, and substituted an artificial nebula; and the observations from April 21 to May 19, 1882 were conducted with this latter. But as the brightness of the comet increased he reverted to the orginal disk. Thus his observations form two series which are not exactly comparable. The entire series of observations, which were obtained on 21 days, from April 21 to June 6, showed that the comet increased in brightness much more rapidly than was to be expected from theoretical considerations and calculations, so that it must be concluded that a very remarkable development of the comet's own light took place. The time when this growth of intensity commenced was in the latter half of May, about the time that the bright lines of sodium were discovered in the spectrum. The photometric observations by themselves would have justified the conclusion that in the middle of May, extraordinary changes took place in the physical condition of the comet; and this conclusion was thus fully confirmed by the revelations of the spectroscope. From the comparison of the nucleus of the comet with the stars D. M. + 49°, No. 3062, and D. M. + 49°, No. 3059, it was found that the nucleus of the comet was equal in brightness to a star of the third magnitude on June 6, whilst on May 19 it only equaled one of the eighth or ninth.

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